Spatial behaviour and survival of translocated wild brown hares

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Fischer, C. & Tagand, R., 2012. Spatial behaviour and survival of translocated wild brown hares. *Animal Biodiversity and Conservation*, 35.2: 189–196.

Abstract

Spatial behaviour and survival of translocated wild brown hares.— The fragility of many populations of brown hares in Western Europe is a concern for managers, hunters and naturalists. We took advantage of a locally high density population to use wild individuals to restock areas where the species had disappeared or was close to disappearing. The aim of the project was to assess the evolution of the spatial behaviour after release using radio–tracking. Over 150 wild brown hares were translocated, one third of which were fitted with radio collars. In addition, fifteen individuals were radio–tagged and released back into the source population as a control. Most individuals settled in less than two months and their seasonal home range, once settled, was similar to that observed in the source population. Mean duration of tracking was not significantly different between the two groups. Moreover, two years after the last translocation, tagged individuals can still be observed, but most hares present are not tagged, which indicates natural reproduction of the released individuals. The translocation of wild individuals thus appears to give encouraging results.

Key words: Brown hare, *Lepus europaeus*, Translocation, Home range, Survival, Monitoring.

Resumen

Conducta espacial y supervivencia de liebres europeas salvajes desplazadas.— La fragilidad de muchas poblaciones de liebres europeas en Europa occidental es una gran preocupación para gestores, cazadores y naturalistas. Aprovechamos la ocasión de disponer de una población local de alta densidad para repoblar con ejemplares salvajes áreas dónde la especie había desaparecido o estaba próxima a la extinción. El objetivo de este proyecto era evaluar la evolución de la conducta espacial tras soltar a los individuos, utilizando el radio–seguimiento. Se trasladaron más de 150 liebres europeas salvajes, a un tercio de las cuales se les puso un collar dotado de un transmisor. Además, quince individuos fueron dotados también con un transmisor, y vueltos a soltar en su población de origen, como grupo de control. La mayoría de los individuos se establecieron en menos de dos meses, y su área de deambulación estacional, una vez establecida, era similar a la observada en la población de origen. La duración media del seguimiento no fue significativamente distinta entre los dos grupos. Dos años después del último traslado, aún pueden ser observados individuos marcados, aunque la mayoría de las liebres presentes en el lugar no están marcadas, lo que indica que ha habido una reproducción natural entre los individuos soltados. Por lo tanto, el desplazamiento de individuos salvajes parece producir resultados esperanzadores.

Palabras clave: Liebre europea, *Lepus europaeus*, Desplazamiento, Área de deambulación, Supervivencia, Monitorización.

Received: 23 XII 11; Conditional acceptance: 10 II 12; Final acceptance: 25 V 12

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ISSN: 1578–665X

Introduction

The fragility of many populations of brown hares (*Lepus europaeus*) in Western Europe is a concern for managers, hunters and naturalists. The influence of multiple factors on the survival of its populations and a habitat under strong competition for space renders conservation efforts particularly difficult. The intensification of agriculture is considered to be a major factor in the decline of hare populations as it leads to a loss of habitat heterogeneity, a reduction of permanent vegetation cover, an increase in the use of pesticides, and precocial mowing of pastures (Hackländer et al., 2002; Rühe & Hohmann, 2004; Baldi & Farago, 2007; Fischer, 2010; Reid et al., 2010). Improving the quality of the habitats is, however, often not enough for the populations to recover (Zellweger–Fischer et al., 2011), and restocking efforts are a widespread additional management tool (Stamatis et al., 2007). However, the effects of this latter method on the survival of the released individuals and on the dynamics of the local hare population are considered and analysed in few instances.

In Switzerland, hare populations have experienced a strong decline since the 1960s as in many areas in Western Europe (Vaughan et al., 2003; Smith et al., 2005). Mean hare density in Switzerland is estimated to be under 3 individuals per 100 ha (Zellweger–Fischer, 2011). Canton Geneva has been an exception the last twenty years, as mean populations were always much higher than the nation's mean, with estimated densities around 12 to 15 individuals per 100 ha. Since 2001, one of the populations in the east of the canton even showed a dramatic increase, reaching a density of over 50 individuals per 100 ha on an area of about 20 km^2 (Nature and Landscape Office, administration of Geneva, unpublished data). During these years, damage to crops due to hares also increased markedly.

This situation led to two contrasting management needs between neighbouring areas. On the one hand, in Geneva the apparent link between increasing densities and the increase of damage on crops (mainly sunflower, soybean, and peas) led to the willingness to reduce hare populations. The option of culling part of the population was soon abandoned however because of the role that the canton plays regionally regarding the conservation of hare populations, because of the emblematic status of the species for the public, and last but not least, because hunting has been abolished in Geneva since 1974. On the other hand, in many surrounding areas, in Switzerland and in France, the interests of local managers are the exact opposite. There, efforts are made to restore or reintroduce populations.

Considering these contrasting management needs, we took advantage of the presence of the locally high density population in Geneva to use wild individuals for restocking experiences in areas were the species had disappeared or was close to disappearing. This management tool, translocation, is increasingly used to restore endangered populations, particularly birds and mammals (Seddon et al., 2007). Regarding hares, however, it is rather unusual. In France, translocation was used since the 1970s either with captive bred leverets (Marboutin et al., 1990) or with wild individuals originating from Central or Eastern Europe (Benmergui et al., 1990). There was thus no consideration for the genetic homogeneity of the released hares. In Italy, translocation experiments with wild hares were conducted on a regional scale (Paci et al., 2006; Pelorosso et al., 2008) , respecting the genetic origin of the local population. However, in these instances results were generally disappointing. Translocation in general is often considered as being unsuccessful as released individuals fail to establish viable populations (Angelici et al., 2000; Teixeira et al., 2007). The main factors explaining the poor success of translocations are prolonged stress during and particularly after translocation when released individuals have to adapt to a novel environment, as well as the increased risks they are exposed to during the first days after release when they move around in search of food resources and cover. In our study we tried to reduce stress to a maximum by reducing the time of handling and transport.

The aim of the project for the areas to be restocked was thus: (1) to assess the evolution of spatial behaviour after release using radio–tracking, and to compare the results with control individuals tagged in the source population; (2) to measure the sustainability of the method in assessing the survival and reproduction potential of the released individuals; and (3) to compare the results with the frequently used release of captive bred individuals, the main hypothesis being that wild individuals would show a better survival after release than captive bred individuals.

Methods

Study areas

The population where hares were captured, the source population, is located in the South–East of canton Geneva. It is dominated by intensive cultivation of cereal crops interspersed by small woods and fallow strips. A large forest constitutes a limit to the north and east, marking the border with France, Lake Geneva constitutes the limit to the west, and the agglomeration of Geneva is the limit to the South (fig. 1). The area is criss–crossed by an intensive road network and traffic is heavy. Hunting was abolished in the canton in 1974 but is still allowed in the neighbouring areas in France.

Hares were released in four different target populations, one in the Canton Valais, Switzerland, and three in Haute–Savoie, France (fig. 1). The target area in the Valais (3000 ha) and two of the target areas in Haute–Savoie (Sciez [1,100 ha] and Arenthon [3,500 ha]) are a mosaic of pastures, crops and woods lying at a similar altitude as the source area (350–450 m). The areas are delimited by roads with heavy traffic and by agglomerations. The last target area in Haute–Savoie, Mieussy (5,200 ha) lies, however, at a much higher altitude (1,500 to 2,000 m). There the landscape is dominated by pastures and prairies, and half of the area is a ski–resort during winter. The area is limited by natural features like high mountain peaks and cliffs.

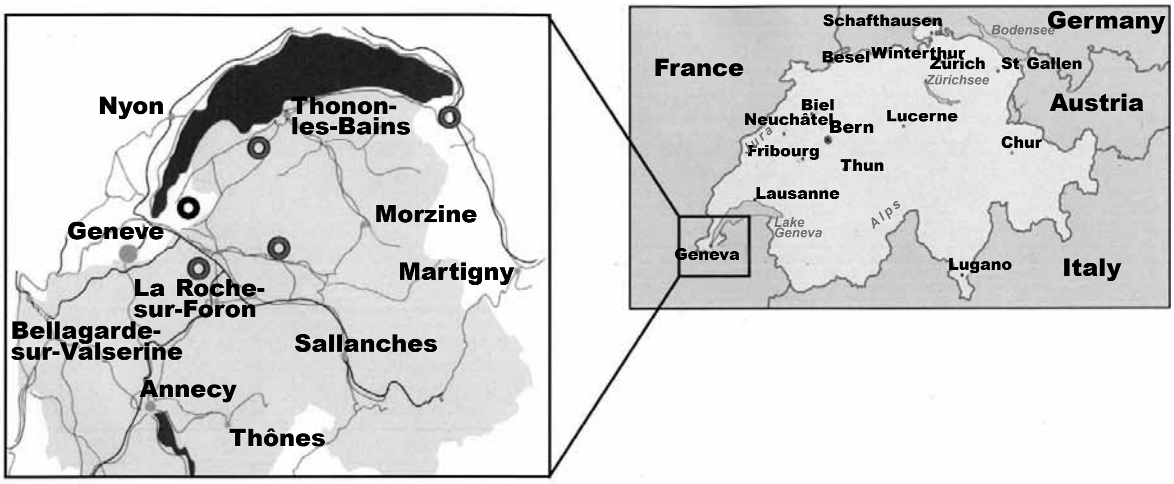

Fig. 1. Situation of the canton Geneva and of the different study sites: ⭘ Source population; ◎ Target populations. (Switzerland is white and France light grey. Lake Geneva is represented in black.)

Fig. 1. Situación del cantón de Ginebra y los distintos lugares de estudio: ⭘ Población de origen; ◎ Poblaciones de destino. (Suiza está en blanco y Francia en gris claro. El lago de Ginebra se ha representado en negro.)

The source population and selected release populations were located in a radius of less than 30 km, except for the Valais distant of 100 km. This allowed reducing time of transport, to release hares of potentially the same genetic origin as the residents, and to release them in areas with similar climatic conditions (with the exception of Mieussy).

To get hares from Geneva, managers of the target areas adopted a commitment to stop hunting activities for at least five years, to participate actively in the capture efforts, to improve the habitats, and to play an active role in the monitoring of the restocked populations by conducting spot–light censuses.

Captures and marking

Most hares were captured using nets after being flushed during silent beats. A few individuals were also captured in cage–traps. Captures were conducted between early November and the end of February in the winters of 2006–07, 2007–08, and 2008–09. Capturing in winter allows beats in agricultural areas without damaging crops and avoids capturing lactating females. Captured individuals were weighed, sexed and ear–tagged. Only those over 3.8 kg were fitted with radio transmitters (TW5SM Biotrack Ltd.) as collars have to be fitted tightly and are thus not suitable for individuals that are not fully grown up. A reflective adhesive was stuck on the ear–tags so they could be seen better during spotlight censuses. All captured hares were then kept in individual transport boxes until release. Some were released back into the source population, directly at the site of capture, as controls. Translocated individuals were released in the various target sites three to five hours after capture.

Captive bred individuals

To compare the results of our translocation project with the more usual restocking method using captive bred hares, we took benefit from a trial of a hunting association located in an area bordering one of our target areas. The association brought 22 individuals from a farm in Brittany (France) and released them after a 12–hour train journey. Before release, we fitted eight of them with collars to monitor their spatial use and survival.

Monitoring

Spotlight censuses were used to determine survival of the released individuals. This method also gives an opportunity to assess population trends and to collect information regarding reproduction success. Even if it does not give precise survival and reproduction rates, the method allows a good insight into the success of the translocation efforts. The number of individuals with tags observed from year to year provides an indication of the survival of the released population, and the proportion of untagged individuals gives an idea on the reproduction success, as all but one target area had no hares left before release and as these areas are largely isolated from potential neighbouring populations. Yearly spotlight censuses have been regularly made for over 20 years. They were, however, more focused on other game species, such as roe deer (*Capreolus capreolus*), in the target areas as hares had not been seen since the early nineties in Arenthon and Sciez, and were only rarely spotted in Mieussy (Fédération de chasse 74, pers. comm.). Spotlight censuses were then intensified as soon as our project was started and homogenised between the different study areas. Since then, sessions are conducted in early March each year and repeated at least 4 times within 3–4 weeks. Spotlight censuses should continue in the future. In this paper we present the results of the last census, in March 2011, that is two years after the most recent release.

The evolution of spatial use and the degree of settlement of the translocated hares were assessed by radio–tracking some of the released individuals. To assess the degree of settlement, that is, the spatial stabilisation, we considered the evolution of the mean distance between two consecutive fixes. As proposed in Moreno et al. (2004), a hare was considered stabilised when for three or more consecutive days this distance was less than all of its averaged values. In addition, an idea of the dispersion distance was given by considering the distance between each successive location and release site (Pépin & Cargnelutti, 1985). In a suitable area, released hares should show a stabilisation of their home range and should not remain erratic. Comparing the stabilised home ranges in the released populations to those of the source population gives a rough idea of the habitat quality, although factors such as hare density (Ferretti et al., 2010) or stress (Teixeira et al., 2007) also play a significant role.

Each individual was located once at night and once during daytime, every second day. Intensive tracking of 8 hours in a row with fixes taken every 30 minutes was performed on every individual on average every second week depending on the number of tracked individuals at a given moment. To avoid any autocorrelation, we considered only fixes separated by more than two hours for the calculation of home ranges. In the mountain area of Mieussy, half the released individuals established in steep slopes with a South – South–west orientation). The accessibility of these areas was particularly difficult in winter, as the snow cover can reach over one meter, but also during the rest of the year because of the steep slippery slopes. Furthermore, this particular topography made the tracking very difficult because of the echoes and because of the shielding effect of the mountain. In this area it was thus often not possible to follow our tracking protocol.

Home ranges were evaluated by the Minimal Convex Polygon (MCP, at 95%), to be comparable to data from the literature, and by the adaptive Kernel method (at 95%, with least–square cross–validation for bandwidth selection). The analyses were conducted using Arcview 9.3 with HRT tools extension. The latter allows to avoid overestimating the area of the home range if location points are clustered (Ryan, 2011) and was thus used for further analysis. Home ranges were only calculated for individuals with more than 50 fixes to avoid an overestimation (Seaman et al., 1999). For individuals that were determined to have settled, home ranges were calculated from the moment of stabilisation. Finally, radio–tracking data also gave an indication of the survival duration of the individuals fitted with transmitters simply by considering the number of days (= radio–days) each tracked individual survived. It allowed a 'mean tracking duration to be determined in each area.

Spotlight censuses were conducted in all target areas as well as in the source area, and should be continued in the long term. The monitoring through radio–tracking was conducted in two of the target areas (Arenthon and Mieussy) and in the source area, as a control.

Results

Between 2006 and 2009, a total of 185 wild Brown hares was captured in the source population. Among these, 159 individuals were translocated to the four target areas (table 1). Of these, 58 were fitted with transmitters. In addition, fifteen individuals were radio–tagged and released back into the source population as controls. The eleven remaining individuals died after capture or during transport.

Survival

For both target areas, the mean tracking duration (= radio–days) of the individuals fitted with transmitters was not significantly different from that of the source population (136 days ± 144 and 173 ± 197 for Arenthon (N = 18) and Mieussy (N = 10) respectively, compared to 165 days ±126 for the source population (N = 13); Mann–Whitney *U*–test: $P > 0.05$).

Considering spotlight counts, the total number of hares recorded two years after the last release varied between 40 and 55% of the number of translocated individuals (table 2). Ten to 30% of them were tagged, and had thus survived for over two years.

Spatial use

After release, hares did not show any preference in the directions taken and thus gave no indication of a possible homing behaviour. Only a minority of them went out of the target areas (11.1% in Arenthon, 9.6% in Mieussy), even after several months of tracking. Evolution of the distances between each successive fix and release point usually stabilised at 758 m (± 316) and 20 days in Arenthon, and at 1,428 m (± 1,185) and 50 days in Mieussy.

At first sight, home ranges in the target areas were significantly larger than for control individuals from the source population (table 3). However, considering that hares in the target areas took 20 and 50 days, respectively, to settle, we calculated home ranges one and two months after release (table 4). Differences between source and target areas were no longer statistically significant . It should be pointed out that there was a high individual variation in home range sizes in all the study areas.

Captive bred individuals

Of the 22 captive–bred hares released, none were re–observed during spot–light censuses conducted nine months later. Eight of them were fitted with collars, and seven of these died within the first 36 hours after release; the last one survived 20 days. Translated into radio–day, captive–bred hares thus survived for a mean of 3.4 (± 6.5) days, meaning significantly less

Table 1. Number of hares released in the different study areas and of individual fitted with transmitters: N. Total number released; F. Females; M. Males.

Tabla 1. Número de liebres liberadas en las distintas áreas de estudio y de individuos equipados con transmisores: N. Número total de individuos liberados; M. Machos; F. Hembras.

Study area	N	F	M	With transmitters	> 50 fixes
Source (Geneva)	15	7	8	15	13
Arenthon	54	28	26	27	18
Mieussy	44	30	14	31	8
Sciez	33	17	16	–	–
Valais	28	16	12	–	–
Total	174	98	76	73	39

Table 2. Results of spotlight counts: * Individuals withdrawn from the population (159 translocated + 11 dead); (1) Two years after last release;

*Tabla 2. Resultado de los censos con focos: * Individuos sacados de la población (159 desplazados + 11 muertos); (1) Dos años después de la última liberación.*

Area	Initial situation	Number released 2006–09	Re–obs.(1)	Without tags(1)	Total obs.(1)
Source	160–210	–170*	None	140–180	140–180
Arenthon	None	54	15	13	28
Mieussy	< 3	44	3	15	18
Sciez	None	33	7	6	13
Valais	None	28	?	?	14

Table 3. Mean home range sizes as calculated by the Minimum Convex Polygon (MCP) and the Kernel method. (Standard deviation is given in brackets.)

Tabla 3. Tamaño medio de cada área de deambulación calculados según el Polígono Convexo Mínimo (MCP) y el método del núcleo (método Kernel). (Desviación estándar entre paréntesis.)

Area	MCP 95%	MCP 50%	Kernel 95%	Kernel 50%
Source (N = 13)	31.8 ha (± 18.8)	7.8 ha (± 6.8)	39.1 ha (± 24.9)	6 ha (± 4.8)
Arenthon (N = 18)	162.4 ha (± 196.7)	25 ha (± 14.3)	118.4 ha (± 113)	16 ha (± 11)
Mieussy (N = 8)	117.2 ha (± 75.6)	15.4 ha (± 8.8)	77.5 ha (± 39.8)	9.3 ha (± 5.1)

than hares tracked in the source population (Mann–Withney *U*–test: $P < 0.0001$). All four individuals for which an autopsy was possible appeared to have died from a collision.

Discussion

The translocation of wild hares appears to give very interesting results. Two years after release, about

Table 4. Comparison of the home range sizes between various areas (Mann–Whitney *U*–test).

Tabla 4. Comparación de los tamaños de las áreas de deambulación entre distintas zonas (test U *de Mann–Whitney).*

	Source–Arenthon	Source–Mieussy	Arenthon–Mieussy
Total duration			
Kernel 95	P = 0.004*	P = 0.059	P = 0.56
Kernel 50	P = 0.012*	P = 0.12	P = 0.4
After one month			
Kernel 95	P = 0.4	P = 0.14	P = 0.45
Kernel 50	P = 0.19	P = 0.14	P = 0.88
After two months			
Kernel 95	P = 0.88	P = 0.37	P = 0.39
Kernel 50	P = 0.51	P = 0.93	P = 1

one fourth of the tagged individuals can still be observed during spot–light censuses. This is a very good result considering that this method is known to underestimate the real abundance of hare populations (Zellweger–Fischer et al., 2011). This is especially true for Mieussy, the target area located in the mountain, as the road network is very poor and the extent of the area sampled is thus limited. For this latter area, results are particularly interesting as hares originating from a cereal crop dominated lowland landscape were translocated to a pasture dominated mountainous area, and this usually in early winter, just before the first snowfall. Furthermore, during the mentioned censuses, conducted two years after the last release, the majority of the hares present were not tagged, which indicates an existing natural reproduction of the released individuals and of their offspring (and indeed we regularly observed leverets). The probability of hares migrating in those areas is very low because of a high degree of fragmentation and due to the absence of any hare populations in neighbouring areas. The individuals without tags are therefore most likely to be born from released hares. The mean duration of tracking of hares fitted with transmitters also indicates good survival. Means in Arenthon and Mieussy are close to those obtained from the source population. Finally, the released hares settled after only 20 days in Arenthon (the lowland area) and 50 days in Mieussy (the area located in the mountain), indicating how adaptable wild animals can be. The longer time to stabilisation observed in Mieussy is likely linked to the difference in environmental conditions between the source area and this target area.

Translocations are often considered to have a low rate of success, particularly because of the induced stress during capture, handling, captivity, transport, release, and acclimation in the release sites leading to a lowered survival (Letty et al., 2003; Pelorosso et al., 2008; Dickens et al., 2010). We tried to reduce this stress to a maximum by reducing the length of each step. Between capture and release we had a mortality rate of 5.9%. Even if it is not possible to give a precise mortality rate for the period after release, the settlement period, our results (re–observation rate after two years, mean tracking duration) suggest a rather high survival rate. An additional concern with translocated animals is the dispersion out of the target area (Dickens et al., *op. cit.*; Ferretti et al., 2010). In this respect, we had again rather good outcomes with less than 15% moving out of the selected areas, and all remaining in directly adjacent areas.

For a translocation programme to be considered successful, it is also important to measure the impact of captures on the source population. In our project, the stability of densities observed in the source area indicates that the disturbances due to capture events and the withdrawal of 170 individuals within three years did not threaten the local population. Populations of hares can be quite robust when living at high densities.

The adaptability of wild hares is also shown by the evolution of home range use of the released individuals. Although Ferretti et al. (2010) observed significantly larger home ranges in translocated hares as compared to residents, this was not the case in our study. Actually, in our study the difference was significant when considering the total dataset, but not anymore when taking in account that hares need a period of acclimation after release that was determined to be between one and two months according to our results. The mentioned authors did not consider this period of acclimation. Stress might be a factor that impairs the stabilisation of released individuals as its effects could reduce their ability to remember the location of vital resources (Teixeira et al., 2007). Furthermore, hares that roam more extensively are more exposed to predation or road casualties and have higher energy expenditure (Ferretti et al., *op. cit.*). Thus, stabilisation of home ranges, with a size comparable to that observed in the source population, indicates that released individuals have adapted to their new environment and that the target areas are therefore suitable. Comparing our results to other studies conducted with similar effort and in similar landscapes, home ranges in Geneva and the target areas are slightly smaller (Marboutin & Aebisher, 1996) or of similar size (Reitz & Léonard, 1994; Kunst et al., 2001).

The value of the results we obtained in our study is enhanced when compared with the poor results recorded with the commonly used release of captive bred individuals. The low performance of this method is striking despite the low number of captive–bred hares we tracked (N = 8). High mortality rates during the first days after release were also reported by other authors for the Brown hare (Marboutin et al., 1990; Angelici et al., 2000). The better success obtained by releasing wild hares rather than individuals bred in captivity has already been documented in other studies (Pépin & Cargnelutti, 1985). So as expected, translocating wild individuals appears to be much more sustainable. It is also more ethical. There are, however, some constraints that need to be dealt with, such as the availability and proximity of a potential source population, and the availability of enough manpower for the captures.

Regarding sustainability, the question arises of how the populations will evolve and survive in the long term in the relatively isolated areas that were restocked in our project. In the absence of an extension of the released population and of exchanges with other populations allowing the introduction of 'new blood' to improve genetic diversity, sustainability remains questionable (Fulgione et al., 2009). Managers in the target areas have now to improve habitat suitability for hares and the connectivity to neighbouring areas.

Acknowledgements

We are most grateful to Gottlieb Dändliker and Franck Péray of the Direction Générale Nature et Paysage (Genève), Guillaume Coursat, Eric Coudurier, and Pascal Roche of the Fédération des Chasseures de Haute–Savoie, and Laurent Loze, from Mieussy, for their valuable help throughout this project. Many thanks also to two anonymous referees for their useful comments on the first draft of our manuscript.

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